Contents

| 1 | Int | roduct | ion | 3 | | | |
|---|-----|---|--|----|--|--|--|
| 2 | Rat | Rational matrices and vector spaces | | | | | |
| × | 2.1 | 1 Algebraic preliminaries | | | | | |
| | 2.2 | Euclie | dean domains of rational functions | 16 | | | |
| | 2.3 | Pole/ | zero structure of a rational matrix | 17 | | | |
| | 2.4 | Wiene | er-Hopf structure of a rational matrix | 23 | | | |
| | 2.5 | Minin | nal basis of a rational vector space | 29 | | | |
| | 2.6 | Prelin | ninary results for matrix pencils | 32 | | | |
| 3 | Rep | oresen | tations of linear time-invariant systems | 40 | | | |
| | 3.1 | Dyna | amical systems | | | | |
| | 3.2 | AR re | presentations | 44 | | | |
| | 3.3 | ARM. | A representations | | | | |
| | 3.4 | First- | order representations | | | | |
| | 3.5 | Syster | Systems with split external variables | | | | |
| | | 3.5.1 | Relation $(F, G, H_y, H_u) \leftrightarrow (E, A, B, C, D)$ | 60 | | | |
| | | 3.5.2 | Relation $(F, G, H_y, H_u) \leftrightarrow (E, A, B, C) \ldots \ldots$ | 65 | | | |
| | | 3.5.3 | Relation $(E, A, B, C, D) \leftrightarrow (E, A, B, C)$ | 67 | | | |
| 4 | Min | Minimality and transformation groups 73 | | | | | |
| | 4.1 | Minin | nality of a P representation | 71 | | | |
| | | 4.1.1 | Results under strong external equivalence | 72 | | | |
| | | 4.1.2 | Results under weak external equivalence | 78 | | | |
| | 4.2 | Minin | nality of a D representation | 79 | | | |
| | | 4.2.1 | Results under strong external equivalence | 80 | | | |
| | | 4.2.2 | Results under weak external equivalence | 87 | | | |
| | 4.3 | Minin | nality of a DZ representation | 90 | | | |
| | | 4.3.1 | Results under strong external equivalence | 90 | | | |
| | | 4.3.2 | Results under weak external equivalence | 93 | | | |
| | 4.4 | 4 Minimality of a DP representation | | | | | |
| | | 4.4.1 | Results under strong external equivalence | 95 | | | |
| | | 4.4.2 | Results under weak external equivalence | 95 | | | |
| | 4.5 | Transf | formation groups | 96 | | | |

| | | 4.5.1 | Results for minimal P representations | 97 | | | |
|---------------------------|---|--|--|-----|--|--|--|
| | | 4.5.2 | Results for minimal D representations | 100 | | | |
| | | 4.5.3 | Results for minimal DZ representations | 103 | | | |
| | | 4.5.4 | Results for minimal DP representations | 104 | | | |
| | | | | | | | |
| 5 | Rea | n in minimal first-order form | 106 | | | | |
| | 5.1 | 1 Realization in pencil form: the abstract procedure | | | | | |
| | 5.2 The pencil realization in terms of a discrete-time behavior | | | | | | |
| | 5.3 | 3 Choosing bases | | | | | |
| | | 5.3.1 | Realization in dual pencil form | 127 | | | |
| | | 5.3.2 | Realization in descriptor form | 131 | | | |
| | 5.4 | Conne | ctions with the Fuhrmann realization | 138 | | | |
| | | | | | | | |
| 6 | 6 Structural invariants | | | | | | |
| 6.1 Observability indices | | | | 144 | | | |
| | | 6.1.1 | Results for P representations | 145 | | | |
| | | 6.1.2 | Results for DP representations | 149 | | | |
| | | 6.1.3 | Results for D representations | 151 | | | |
| | 6.2 Controllability indices | | | | | | |
| | | 6.2.1 | Results for DP representations and P representations | 156 | | | |
| | | 6.2.2 | Results for D representations | 160 | | | |
| | 6.3 | The in | put-output structure | 162 | | | |
| | | 6.3.1 | Results for P representations | 167 | | | |
| | | 6.3.2 | Results for DP representations | 177 | | | |
| | | 6.3.3 | Results for D representations | 179 | | | |
| 7 | 7 Conclusions | | | | | | |
| | | | | | | | |
| Bi | Bibliography | | | | | | |
| In | Index | | | | | | |
| | | | | | | | |